New Absorption Liquids for the Removal of CO2 from Dilute Gas Streams using Membrane Contactors

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Combined Gas-Liquid Reaction and Liquid-Liquid Extraction for Production of Hydrogen Peroxide

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Anthraquinone process, which is commonly used for production of hydrogen peroxide, includes an oxidation step where hydrogen peroxide is formed by the reaction between anthrahydroquinones and oxygen in an organic solvent. Oxidation is succeeded by extraction where hydrogen peroxide is extracted from the organic liquid by water and aqueous peroxide solution obtained. Oxidation is usually carried out in an empty or packed bubble column and extraction in a sieve-plate column. A new process was developed which allows the oxidation and extraction take place in the same space. The process is carried out in a tubular reactor where three phases are flowing concurrently. Both the equipment and plant size would be reduced considerably. The process has been tested in bench-scale but not in full production scale.

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Water Removal by Reactive Stripping for a Solid Acid Catalyzed Esterification in a Monolithic Reactor

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Solid-acid catalyzed esterifications are attractive replacements for processes using conventional homogenous catalysts. However, the esterification of an alcohol with a carboxylic acid is equilibrium limited and produces water, which inhibits a solid acid catalyst. A novel type solid-acid coated monolithic reactor is presented in which water can be removed from the liquid by means of reactive stripping. In this manner the catalyst inhibition is overcome and complete conversion can be reached. The advantages of this reactor concept are demonstrated by both experiments and modeling of the reactor.

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Reactive Extraction of Acids on Metals – The State of the Art of Column Design

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Liquid ion exchangers are used in reactive extractions and the modelling of reactive phase equilibria with Gibbs excess models takes into account complex formation in aqueous electrolytes or organic media. The chemical kinetics and effective diffusivity is evaluated in small scale laboratory devices and applied in models using the chemical potential as driving force. The simulation of lab-scale columns is performed on simple hydrodynamic models, whereas for industrially sized equipment droplet populance based modelling is recommended. Parameter estimation in regard to this is discussed and stirred column simulations are presented.

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New Absorption Liquids for the Removal of CO_2 from Dilute Gas Streams using Membrane Contactors

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The concept of using membrane modules as gas-liquid contactor is quite well established. The compactness of the equipment and high mass transfer rate per unit contactor volume makes it ideally suitable for offshore applications. Stable operation of the membrane gas absorption systems is one of the major challenges in exploiting it on an industrial scale. The problem is more acute in case of removal of CO_2, where aqueous alkanolamine solutions are widely used. Aqueous alkanolamine solutions wet the cheaper polyolefin microporous membranes. As the gas has to diffuse through the liquid inside the pores, the mass transfer resistance increases tremendously and results in very poor performance of the contactor. So, there is need for the development of suitable absorption liquids to enable the use of cheaper polyolefin membranes. Dedicated absorption liquids called CORAL (CO_2 Removal Absorption Liquid) have been developed by TNO (The Netherlands), for CO_2 recovery using membrane contactors. The paper illustrates the properties and performance of the absorption liquids in compari-

son with aqueous alkanolamine solutions. The experimental use of CORAL liquids in a single fiber membrane contactor is shown and the fluxes are compared to these predicted by a numerical model. The agreement between model predictions and experimental results is reasonably good.

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Multi-functional Trickle Bed Reactor for Alkylacetates Synthesis

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The esterification reaction of acetic acid and ethanol was investigated. The reaction was occurred in a trickle bed reactor, filled by a strong acid ion-exchanger resin. The influence of temperature and concentration of reaction component to the reaction rate was studied. The evaporation and consequently separation of vapor and liquid phases shifted the chemical equilibrium and led to the production of high concentrated ethylacetate.

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The Reaction Column as a Multifunctional Reactor – Always the Best Choice for Reactive Distillation?

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Reactive and Catalytic distillation is applied specifically to reversible chemical reactions in the liquid phase, in which reaction equilibrium limits the conversion of the reactants. In this contribution an overview is given about the different equipment options both for homogeneous and heterogeneous catalysis. A column turns out not in any case to be the best solution for a multifunctional reactor. Separation efficiency, residence time and catalyst system have to be designed and adjusted specially for any single case. On this field future research work has to be done because the scale up procedure often is decisive for the realisation of a process as an industrial plant.

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Kinetics-Based Design of Reactive Distillation for Esterification of Lauric Acid with 2-Ethylhexanol

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The reactive distillation process for esterification of lauric acid with 2-ethylhexanol was studied by simulation with Aspen Plus™. Sulfated zirconia was used as catalyst due to its high activity, selectivity and thermo-stability. Parameters of thermodynamic and of chemical kinetics models were found by experimental measurements. The reactive distillation process is feasible for obtaining high purity ester at high yield. Water can be removed quantitatively by taking advantage from heterogeneous phase equilibrium. The sensitivity analysis points out the effect of reflux ratio, number of stages, catalyst loading, liquid hold-up and feed temperature. The catalyst distribution was optimised for 99.9% lauric acid conversion.

Figure.
RCM in homogeneous liquid region (left side) and tie lines in the heterogeneous liquid region (right side) at 32 kPa.